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# CROP-TREE THINNING OF PONDEROSA PINE IN THE PACIFIC NORTHWEST

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## ABSTRACT

*Three Pacific Northwest thinning studies showed that diameter growth of young ponderosa pine was substantially increased by cutting all trees within 5 to 8 feet of the crop tree. An additional increase in diameter growth was obtained by overstory removal. Thinning did not increase height growth of young crop trees, but overstory removal did.*

During the 1930's in some parts of the United States, thinning ponderosa pine (*Pinus ponderosa*) changed from area to the crop-tree method.[1] This was largely an economy move simply because the crop-tree method did not require hand cutting by axe of as many trees as did area thinning. In more recent years, the advent of the lightweight powersaw has given preference to area thinning, although some crop-tree thinning is still being done in conjunction with pruning.

This paper presents results of three crop-tree thinning experiments established at a time when the crop-tree method seemed advisable for economic reasons.

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[1] In this note, crop-tree thinning is the cutting of all trees within a designated distance of a tree to be left as contrasted to area thinning where all trees are cut except selected leave trees.

Mowat[2] has reported on several earlier crop-tree thinning studies made in the Pacific Northwest. Thinning treatments varied from removing only trees with interlacing crowns to cutting all trees whose crowns were within 3 feet of the crop tree. Differences between growth of released and unreleased trees were small. Heavily released trees grew at the rate of only about 1 inch per decade compared to 0.7 inch for selected crop trees in the unthinned stand. Furthermore, these early experiments did not show any clear-cut effect of overstory on understory tree growth and vice versa.

The studies reported here go a step further as some crop trees were released to a point that approached area thinning. In addition, the interrelationships of overstory and understory tree growth were examined. Results are important to land managers who have trees already released by the crop-tree method and to managers who intend to embark on an extensive thinning program in ponderosa pine.

## THE THREE STUDIES

### Chelan Study

This experiment was located 15 miles south of Twisp, Washington, on the edge of the 1929 Camas burn on a high IV site.[3] Reproduction, composed mostly of ponderosa pine but with a sprinkling of Douglas-fir, was established from a natural seed source after fire. The young trees grew rapidly for 10 years, but competition soon reduced individual tree growth to very slow rates. When the study was initiated in 1953, the sapling and small pole stand was 23 years old and contained about 2,500 trees per acre. A few overstory trees were present around the perimeter of the plot.

The study plot, 3 by 5 chains, was subdivided into four subplots 1.5 by 2.5 chains. From the total of 140 ponderosa pine crop trees selected on the plot, 25 trees were randomly chosen on each subplot as study trees. Two of the subplots were randomly selected for crop-tree release and two left unthinned.

Treatment consisted of cutting all stems within 8 feet of the crop tree's bole. This procedure sometimes resulted in overlapping of cut circles and sometimes in separation of cut circles by islands and strips of uncut trees.

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[2] Mowat, E. L. Thinning ponderosa pine in the Pacific Northwest. U.S.D.A. Forest Serv. Pacific Northwest Forest & Range Exp. Sta. Res. Pap. 5, 24 pp., illus. 1953.

[3] Meyer, Walter H. Yield of even-aged stands of ponderosa pine. U.S. Dep. Agr. Tech. Bull. 630 (rev.), 59 pp., illus. 1961.

Height and diameter were measured on all crop trees in 1953 and five growing seasons later in 1958. In addition, a count by 1-inch diameter classes was made of all living trees within an 18.6-foot radius (one-fortieth acre) around each tagged crop tree.

## Snoqualmie Study

This experiment was located in a stand consisting of scattered old-growth ponderosa pine overstory trees with a dense even-aged understory. Site was IV.[4] Existing stand basal area at the time of study establishment averaged 130 square feet per acre of which 40 square feet was overstory. Understory trees averaged about 1,500 per acre.

Two plots approximately 10 acres each were established in 1951 on the south fork of the Tieton River about 50 miles west of Yakima. Fifty study trees in each plot were randomly selected from previously marked crop trees. On one plot, all trees within 7 feet of the crop trees were cut. Crop trees on the other plot were not released.

Study trees were tagged 4.5 feet from the ground and height and diameter measured in 1951, 1956, and 1961. Also, a count by 1-inch diameter classes was made of all living trees within an 18.6-foot radius around each tagged crop tree. Tree vigor was recorded for each crop tree. In dense thickets, crop-tree spacing was close enough so that cut circles overlapped; but where stocking was sparse, competition between trees low, and good crop trees difficult to find, spacing was wide.

## Metolius Study

This was the most extensive ponderosa pine crop-tree thinning study made in the Northwestern United States. It was located about 20 miles north of Sisters, Oregon, in the Abbot Butte area at an elevation of 3,200 feet. Topography varied from flat to gentle southwesterly slopes. Overstory trees indicated an average site IV.[5] Although no local records are available, local precipitation was estimated at 25 inches per year.

The stand before treatment consisted of overmature trees averaging 13,400 board feet per acre. Overstory mortality from bark beetles has been fairly heavy as evidenced by numerous snags. At the time of study establishment, overwood was considered light compared to other mature stands on the Deschutes National Forest. No light ground fires have occurred for about 40 years, and a fairly dense understory of ponderosa pine saplings and poles 10 to 25 feet high and 1 to 5 inches in diameter developed. The understory, originating after a heavy fire, was even aged at 63 years in 1951, when the study was established. Before treatment, there was considerable variation in tree density and thus tree size. Numbers of understory trees ranged from 1,590 to 5,460 per acre and averaged 3,200.

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[4] See footnote 3.

[5] See footnote 3.

Original objectives of the study were to determine

(1) optimum thinning distance around each crop tree,
(2) most desirable crop-tree spacing,
(3) effect of overstory on growth of released and unreleased trees, and
(4) effect of understory on overstory growth.

The experiment was established on four 20-acre plots. On two randomly selected plots all merchantable overstory was removed. On the remaining two plots, a light selection cut in the overstory was made which removed about 22 percent of the existing volume, leaving about 10,500 board feet per acre standing. In each 20-acre plot, treatments were assigned at random to five 4-acre subplots.

The five treatments assigned to subplots consisted of crop-tree selection with the following specification:

| Average crop-tree spacing | Circle of release diameter | Theoretical area thinned |
|---|---|---|
| (Feet) | (Feet) | (Percent) |
| 15 | 0 | 0 |
| 30 | [1] 10 | 9 |
| 30 | [2] 15 | 20 |
| 15 | 10 | 35 |
| 15 | 15 | 79 |

[1] See figure 1.

[2] See figure 2.

Forty crop trees in each 4-acre subplot were randomly selected for growth measurements. Trees were tagged and diameter measured at breast height to the nearest 0.1 inch and height measured to the nearest 0.1 foot with a jointed aluminum pole. Measurements were taken in 1951, 1956, and 1961, giving a 10-year record of growth.

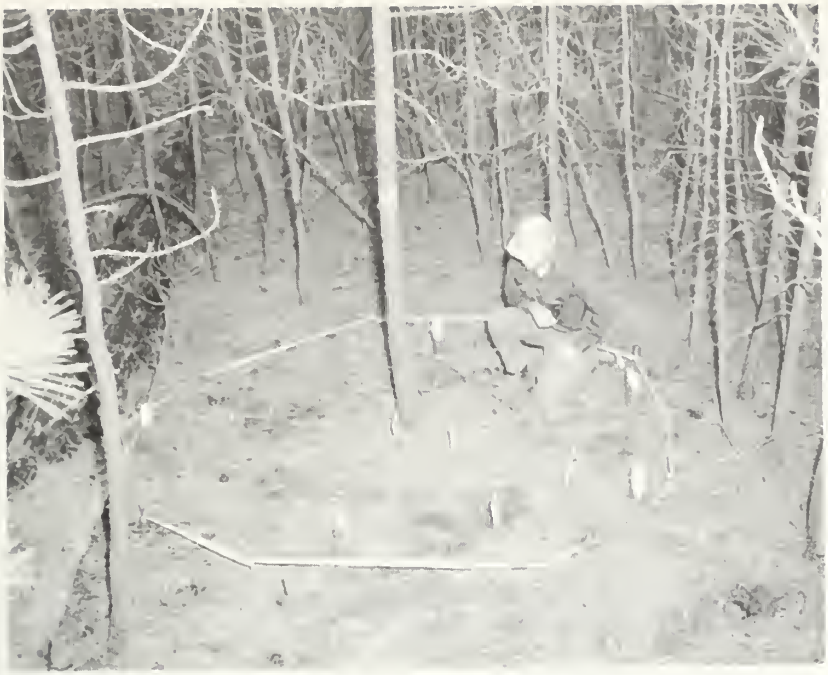

Figure 1.--*All trees within 5.0 feet of this crop tree were cut.*

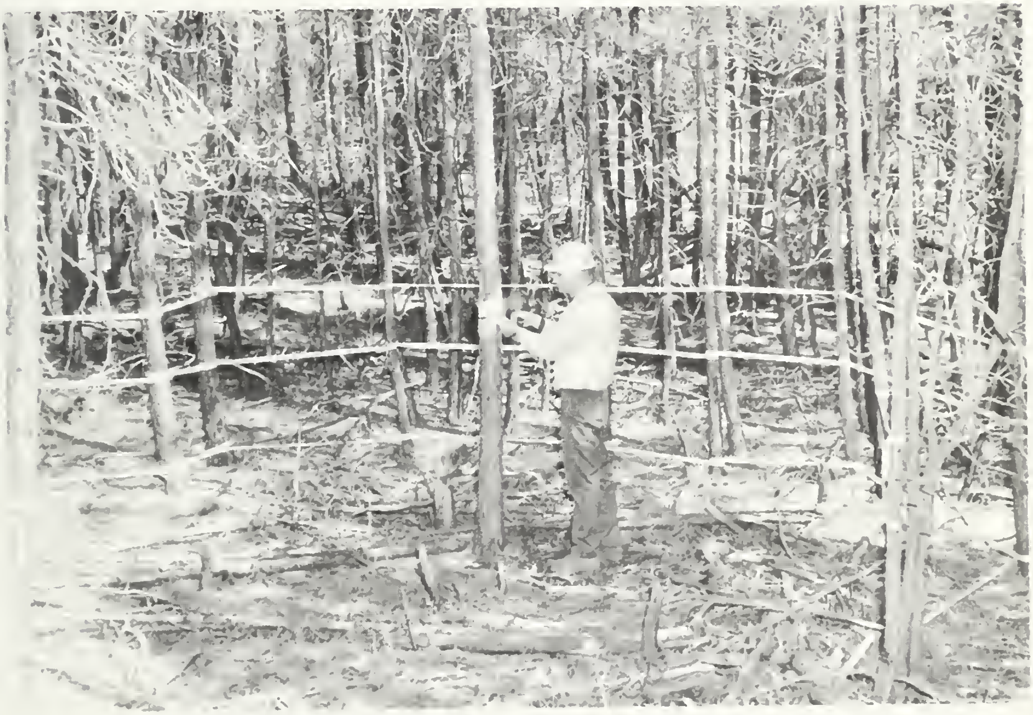

Figure 2.--*All trees within 7.5 feet of this crop tree were cut. Ribbons designate the boundaries of the release circle.*

As an index of existing and past competition, standing and cut trees within an 18.6-foot (1/40-acre) circle of the crop tree were measured in diameter and basal area computed. As an index of overwood competition, all trees 8 inches d.b.h. and larger within a 1/4-acre circle of each of 80 randomly selected crop trees were measured in diameter and basal areas were computed. For evaluation of the effect of thinning on reserve overwood trees on partial-cut plots, 10 overstory trees were chosen and tagged in areas of the subplots representing fairly heavy understory tree competition and little effect from cutting other large trees. Increment cores were extracted from overstory trees to determine growth differences before and after thinning.

## RESULTS

### *Diameter Growth*

Released trees grew more in diameter than unreleased trees in all three studies (table 1). Diameter growth was increased to the rate of nearly 2 inches per decade by crop-tree thinning. In all cases, larger trees grew faster than smaller trees (fig. 3). Tree vigor, which included crown length and density and needle length and color, was a better indicator of crop-tree growth potential than tree size (figs. 4 and 5). High vigor trees responded better to release than low vigor trees; however, it was apparent in the Metolius study that low vigor trees do maintain the capacity to respond, indicating the validity of the common practice of leaving a low vigor tree where necessary to stock an area.

Table 1.--*Average diameter growth of released and unreleased crop trees on each study*

| Study | Released crop trees | | Unreleased crop trees | |
|---|---|---|---|---|
| | First 5 years | Second 5 years | First 5 years | Second 5 years |
| | - - - - - - - - - - - Inches | - - - - - - - - - - - | | |
| Chelan | 1.06**[1] | -- | 0.62 | -- |
| Snoqualmie | .95** | 0.80** | .53 | 0.45 |
| Metolius | .82* | .92* | .59 | .72 |

[1] Test of significance between comparable means of released and unreleased stands:

** Significant at 1-percent level.
* Significant at 5-percent level.

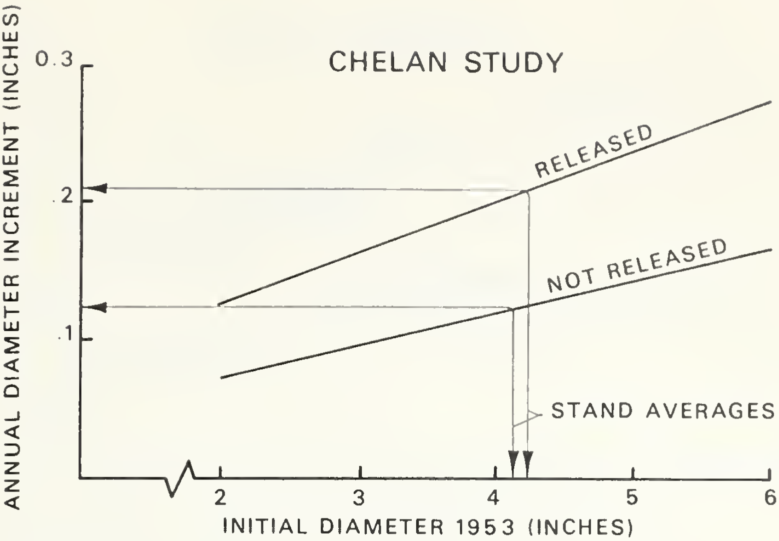

Figure 3.--*Average annual diameter increment in relation to initial diameter.*

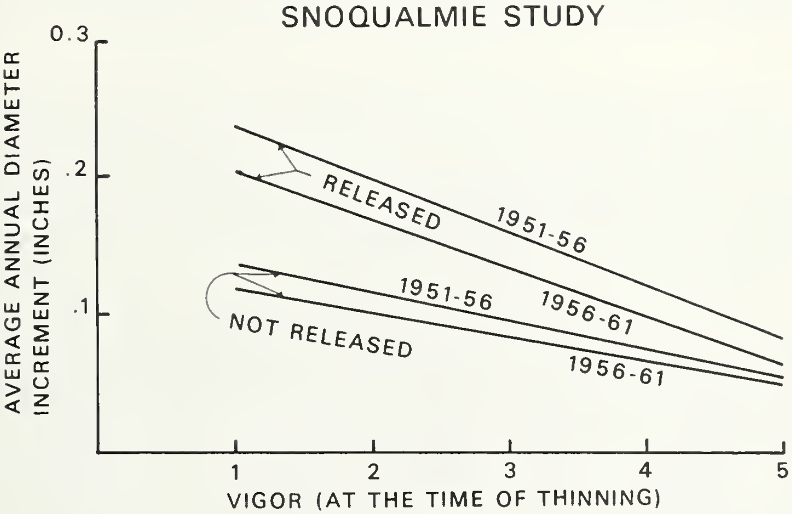

Figure 4.--*Relationship of annual diameter increment of released and unrelased trees to crop tree vigor. Trees were rated for vigor on a scale from 1 to 5. Number 1 vigor class is a tree of high vigor having more than 55 percent of its height in crown contrasted to number 5, the lowest vigor class, having from 10 to 30 percent of its total height in crown, with short, thinly distributed needles.*

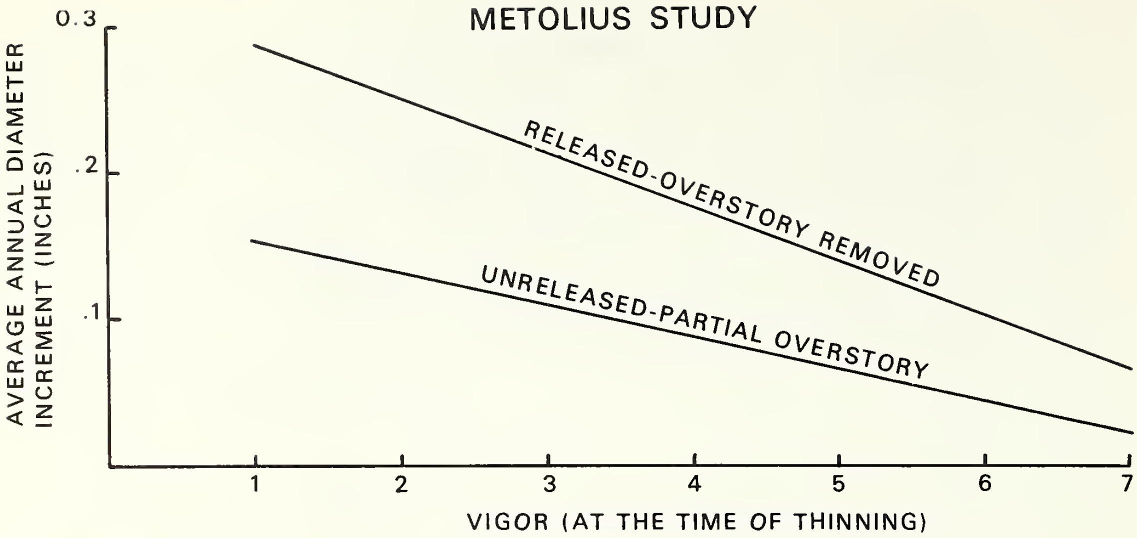

Figure 5.--*Relationship of annual diameter increment to tree vigor with treatment. Trees rated for vigor on a scale from 1 to 7. Number 1 vigor class denotes a tree of high vigor having more than 55 percent of its height in crown contrasted to number 7, the lowest vigor class, having less than 10 percent of the total height in crown, and with short, thinly distributed needles.*

Diameter growth was inversely correlated with basal area of competing trees within the 18.6-foot circle around the crop tree (fig. 6). For example, in the Chelan study, trees that grew 1 inch per decade had competition surrounding them at the rate of about 160 square feet per acre compared to only 50 square feet where trees were growing 2 inches per decade.

In the Metolius study, the 15-foot circle of release with 15-foot spacing where overstory was partially removed (fig. 7) provided significantly better growth to crop trees than the other three degrees of release and spacing. No thinning treatment was significantly outstanding where the overstory was completely removed. The treatment of 10-foot release with 30-foot spacing and complete overstory removal appears outstanding (fig. 7). However, on-the-ground examination of this treatment revealed that growth can be related to a large amount of logging damage to understory trees surrounding released crop trees.

Removal of merchantable overstory improved diameter growth of crop trees in the Metolius study (fig. 7). Trees on plots where the overstory was removed grew 2.1 inches per decade compared to 1.3 inches where part of the overstory was left (significant at the 1-percent level). Unreleased trees were affected as well as released trees. Crop-tree diameter growth in the unreleased stand was reduced an average of about 46 percent by the presence of an overstory.

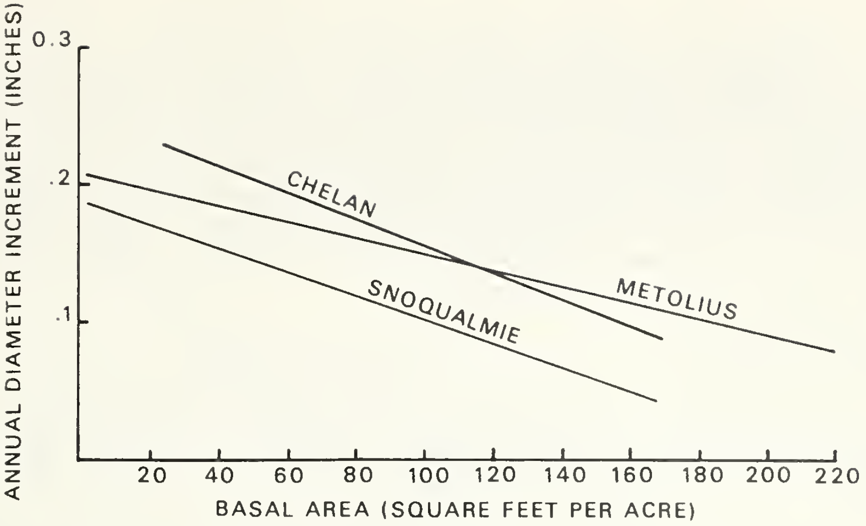

Figure 6.--*Relation of average annual diameter increment to the basal area of living tree competition within an 18.6-foot radius around each crop tree (one-fortieth acre). (Released and unreleased trees combined in each experiment.*

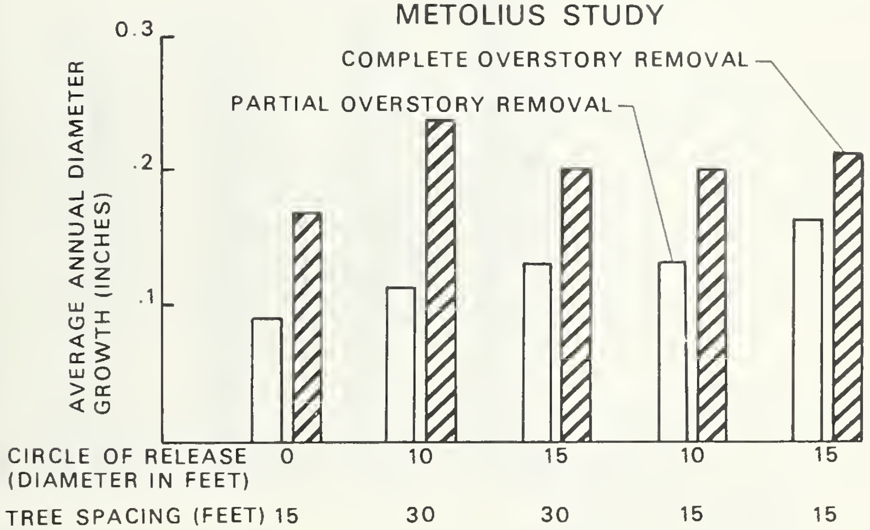

Figure 7.--*Average annual diameter growth of saplings and small poles during the 10 years after release.*

Attempts to derive a prediction equation for diameter growth by use of multiple regression techniques were not successful. Using the independent variables initial diameter, vigor, cut basal area, overstory basal area and basal area of the young stand in a 1/40-acre circle around the crop tree, the author was able to account for only 56 percent of the variation in diameter growth. Vigor was always the strongest predictor variable; however, it was strongly intercorrelated with some of the other variables.

### *Height Growth*

Thinning did not affect height growth. Crop trees on the Chelan study grew almost a foot per year and those on the Snoqualmie study averaged about 0.7 foot per year.

The Metolius study showed a trend (approaching significance at the 5-percent level) for overstory trees to reduce height growth of crop trees during the second period of observation (fig. 8). Annual height growth averaged 0.66 foot where overstory was completely removed and 0.59 where there was a partial overstory.

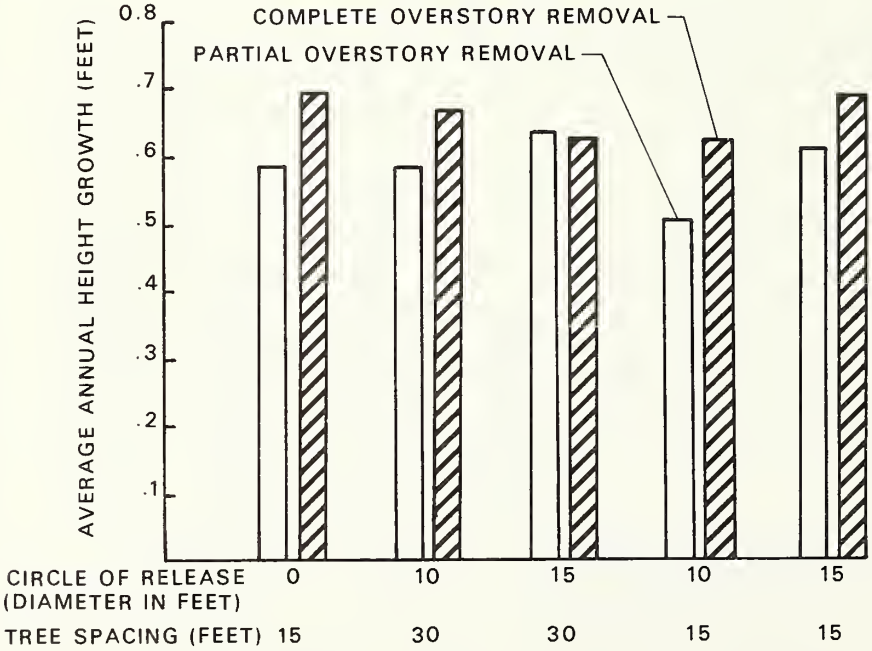

Figure 8.--*Average annual height growth of saplings and small poles during the second 5-year period after release.*

Attempts to predict crop-tree height growth under varying stand conditions were made with some success. For example, when the variables initial height, previous 5-year height growth, basal area cut around the crop tree, overstory basal area, and basal area of the young stand were used, 68 percent of the total variation in height growth could be accounted for. Past height increment and vigor appeared to be the most important variables.

### *Overstory Tree Growth*

There is good evidence to indicate that understory saplings and poles are competing with overstory trees for soil moisture and nutrients. For example, overstory trees grew better in diameter after understory thinning than before. Furthermore, the greater the amount of basal area removed, the more overstory trees responded to reduced competition (fig. 9). Where 60 percent of the basal area of the understory stand was removed (15-foot spacing and 15-foot circle of release), overstory trees grew 1.4 times better after thinning than 5 years before thinning. Before thinning, overstory trees were growing at an average diameter rate of about 0.9 inch per decade, but cutting 60 percent of the understory increased this rate to about 1.3 inches per decade.

## CONCLUSIONS

The most useful conclusion that can be drawn from these studies is that ponderosa pine overstory can retard understory tree growth. And conversely, an understory of saplings can hold back diameter growth of overstory trees.

These studies also show that acceleration of diameter growth can be accomplished by the crop-tree thinning method. In all three studies, diameter growth rates averaged about 2 inches per decade where crop trees were released and overstory was not present. Similar growth rates have been reported for area thinning studies[6] [7] where stands were thinned to about 13 feet. Growth rates above 2 inches per decade were reported in stands where 18- and 26-foot spacings were used and where competing vegetation was removed.

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[6] Barrett, James W. Response of ponderosa pine pole stands to thinning. Pacific Northwest Forest and Range Exp. Sta. U.S.D.A. Forest Serv. Res. Note PNW-77, 11 pp., illus. 1968.

[7] Barrett, James W. Spacing and understory vegetation affect growth of ponderosa pine saplings. Pacific Northwest Forest and Range Exp. Sta. U.S.D.A. Forest Serv. Res. Note PNW-27, 8 pp., illus. 1965.

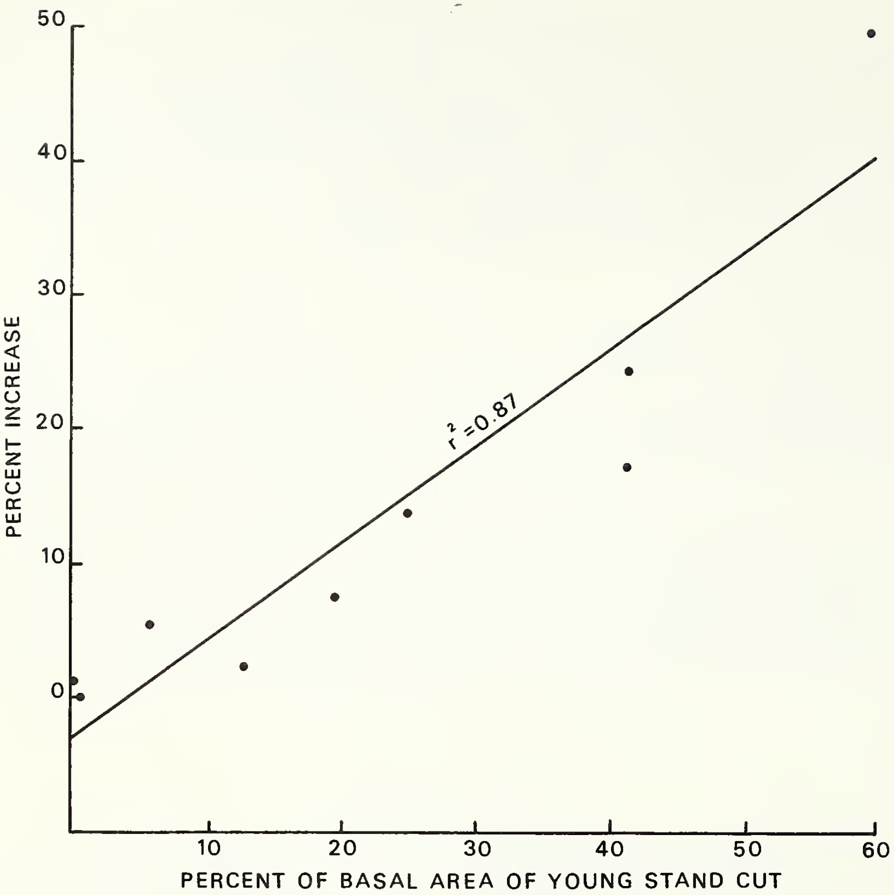

Figure 9.--*Percent increase in diameter growth of overstory trees by cutting varying amounts of the understory. Each dot represents average growth of 10 trees.*

One is tempted to speculate on the length of time that will elapse before the area in the circle of release in crop-tree thinning will be occupied by roots of the released tree, roots of trees surrounding the circle, and crowns of both, and when diameter growth of crop trees will slow to less desirable rates. This or past experiments will not tell us, but a useful conclusion might be drawn by mentally comparing the 15-foot circle of release and 15-foot spacing to 15-foot spacing with area thinning. One could surely expect the crop-tree thinned trees to slow down first simply because there is more competition from uncut trees between circles.

This and other recent ponderosa pine thinning studies[8/] [9/] [10/] in the Pacific Northwest indicate that in areas of limited rainfall all living trees in a densely stocked stand are in competition for soil moisture and nutrients. Therefore, ideally, these two important constituents for growth should be allocated only to (a) trees that are capable of adding reasonable increments of usable wood, (b) usable forage, and (c) trees desired for esthetic purposes.

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[8/] Barrett, James W., and Youngberg, C. T. Effect of tree spacing und understory vegetation on water use in a pumice soil. Soil Sci. Soc. Amer. Proc. 29: 472-475, illus. 1965.

[9/] See footnote 6.

[10/] See footnote 7.